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REED SOLOMON ENCODER/DECODER

OPERATING INSTRUCTIONS

FEBRUARY, 1976

CNI SYSTEMS ENGINEERING

PREPARED UNDER CONTRACT: N62269-75-C-0503

DATA ITEM A007

800745

AVIONICS DIVISION IT

390 Washington Avenue, Nutley, N.J. 07

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FOR

DEPARTMENT OF THE NAVY, NAVAL AIR DEVELOPMENT CENTER

BY: ITT AVIONICS
500 Washington Avenue
Nutley, New Jersey 07110

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Reed-Solomon
Encoder
Decoder
Round Trip Timing
Microprocessor
Galois Field
Errata

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this program is to build a Reed-Solomon encoder/decoder capable of a 384 word/second (approx. 57.6 KBPS) throughput rate in a cost effective and practical manner.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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20. ABSTRACT

ITT Avionics has built and successfully tested a RSED laboratory breadboard that was funded under contract N62269-75-C-0503 (Naval Air Development Center). A summary of the engineering tests is listed below.

Encoding Time	<150 microseconds
Round Trip Timing Detection	< 20 microseconds
Decode Time	Decode time is dependent on Errata. Refer to section 5 of report number D11801 for decode times.

OPERATING INSTRUCTIONS

INTRODUCTION

Data Item A007 Operating Instructions describes the following:

- Equipment Set Up
- Function of front panel controls, selectors and indicators
- Input/Output Data
- Mode Control
- Test Point Description

EQUIPMENT SET UP

The Reed Solomon Encoder/Decoder is a self contained unit. The unit requires 115 volts 60 Hertz primary power and +5 volts dc at 15 amps logic power.

CAUTION

Make sure +5 volts is set to +5 volts $\pm$ 1% with overvoltage protection set for +6.5 volts. In addition, make sure air circulation blower comes on when the primary power is applied. See Figure 1.

FUNCTION OF THE FRONT PANEL CONTROLS AND INDICATORS

The following is a general description of the Reed Solomon Encoder/Decoder controls and indicators. This description will familiarize the operator with their function and figure 2 shows their location.

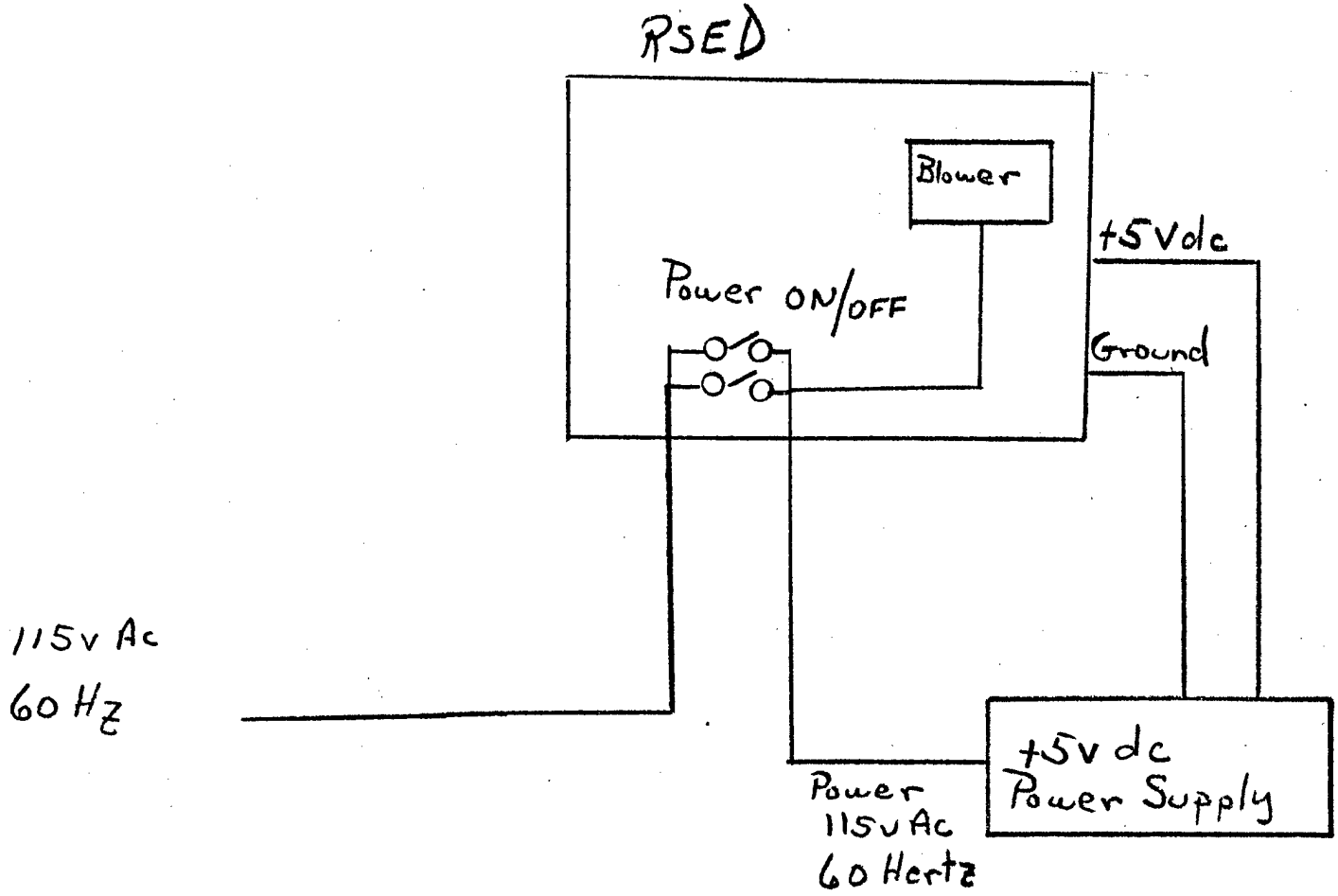

Figure 1
Power Connections

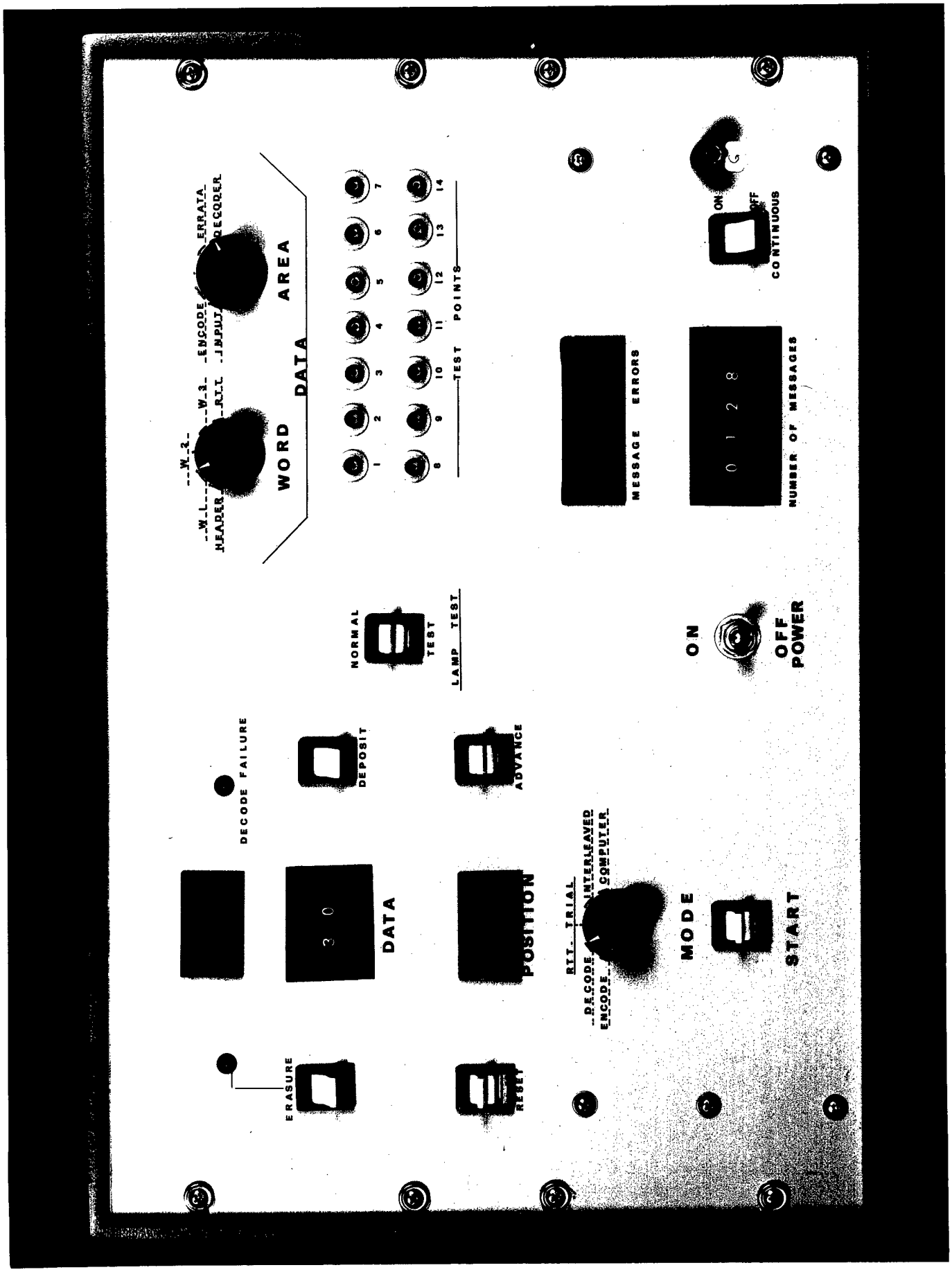
W.2
W.1
HEADER
W.3
R.S.
ENCODE
INPUT
ERRATA
DECODER
WORD DATA AREA
1 2 3 4 5 6 7
8 9 10 11 12 13 14
TEST POINTS
MESSAGE ERRORS
0 1 2 8
NUMBER OF MESSAGES
ON
OFF
CONTINUOUS
NORMAL
TEST
LAMP TEST
ON
OFF
POWER
DECODE FAILURE
DEPOSIT
ADVANCE
ERASURE
RESET
3 0
DATA
POSITION
R.I.T. TRIAL
DECODE
ENCODE
INTERLEAVED
COMPUTER
MODE
START

Figure 2

Power:	The power switch is used to apply primary power (ON/OFF) to the unit.
Mode:	This is a five position rotary switch that allows the operator to select the desired modes of operation which are Encode, Decode, RTT Trial, Interleaved and Computer. (Computer position not active).
Start:	This is a spring loaded switch that starts the selected mode of operation when depressed.
Number of Messages:	This is a set of thumbwheel switches (4 digits) that selects the number of messages from 0000 thru 9999.
Continuous:	This is an on/off switch which overrides the number of messages selected to enable a continuous message structure.
Advance:	Advances the position of the displayed character (spring loaded on/off switch).
Reset:	Resets the data to its initial position (Spring loaded switch).
Position:	This is a two digit decimal display that indicates the position of the displayed character (00 thru 31) within the word.

Deposit: This is a spring loaded switch that deposits the selected data character in the respective data position when activated.

Erasure: This is an on/off switch that allows the insertion of an erasure in a respective data position in conjunction with the deposit switch.

Data: This is a set of thumbwheel switches (2 digits) that selects the data magnitude to be entered (00 thru 31). If a number greater than 31 is selected the data display will blink on and off at a slow rate indicating an invalid character magnitude has been selected.

Data (Display): This is a two digit display that indicates the character magnitude or number of errors. If a number greater than 32 is displayed, the display will blink on/off at a slow rate indicating an invalid character has been selected.

Erasure Indicator: This is a red light emitting diode that indicates that a particular data character is an erasure.

Decode Failure: This is a red light emitting diode that indicates that the RSED has declared the output word a failure (because of excessive errata).

Lamp Test: This is a spring loaded on/off switch that energizes all the indicators and displays when depressed.

Data Word: This is a five position rotary switch that selects the respective Data Word (Header, W1, W2, W3, RTT).

Data Area: This is a four position rotary switch that selects the respective Data Area (Input, Encode, Errata, Decoder).

Number of Errors: This is a four digit decimal display that displays the number of message errors (from 0000 thru 9999) that were detected by the test set. Note: If multiple words were detected to be in error, the count will be incremented by only 1 number.

INPUT/OUTPUT DATA

The RSED operator manually inserts input data or displays output data as follows:

Input Data (Refer to Figure 3)

Set Data Area to Input, Data Word to Header, Number of Messages to 0001 and continuous to off. See figure 3 for organization of Data Areas.

Insert 4 data characters into the header by setting data thumbwheel switches to desired character magnitude, pressing deposit and advancing to the next position. Set Data Word to W1 and insert 15 data characters, then set Data Word to W2 and insert 15 data characters, set Data Word to W3 and insert 15 data characters and

finally set Data Word to RTT and insert 4 data characters. At this point, the input data area is loaded with data.

Set mode control to encode and press the start switch. At this point, the input data has been encoded and can be checked for accuracy by comparing the encoder Data Area with the data contained in Appendix A.* Appendix A contains 1000 (16,4) and 1000 (31,15) codewords. Also at this point the errata Data Area contains the same data as the encode Data Area. The RSED operator can now insert errors and erasures into the errata Data Area which will be inputted to the decoder.

Errata is inserted as follows:

Set Data Area to Errata, Data Word to Header, Number of Messages to 0001 and continuous to off. Insert errors by changing the magnitude of the displayed characters and erasures by turning the erasure switch to on for the character to be tagged as an erasure. In addition the magnitude of the erasure is to be changed (zero is recommended). Repeat for W1, W2, W3 and RTT Trial.

Set mode control to decode and press the start switch. At this point, the errata data has been inputted to the decoder, decoded and the results deposited in the decoder data area. The decoder Data Area can be checked for accuracy by comparing the input Data Area with the Decoder Data Area. The characters of the decoder are checked automatically by the test set against the characters of the original data for accuracy. Each time one or more of the words contain one or more character errors, the entire message is counted as incorrect and the message error display is incremented.

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* Appendix A is part of Data Item A003.

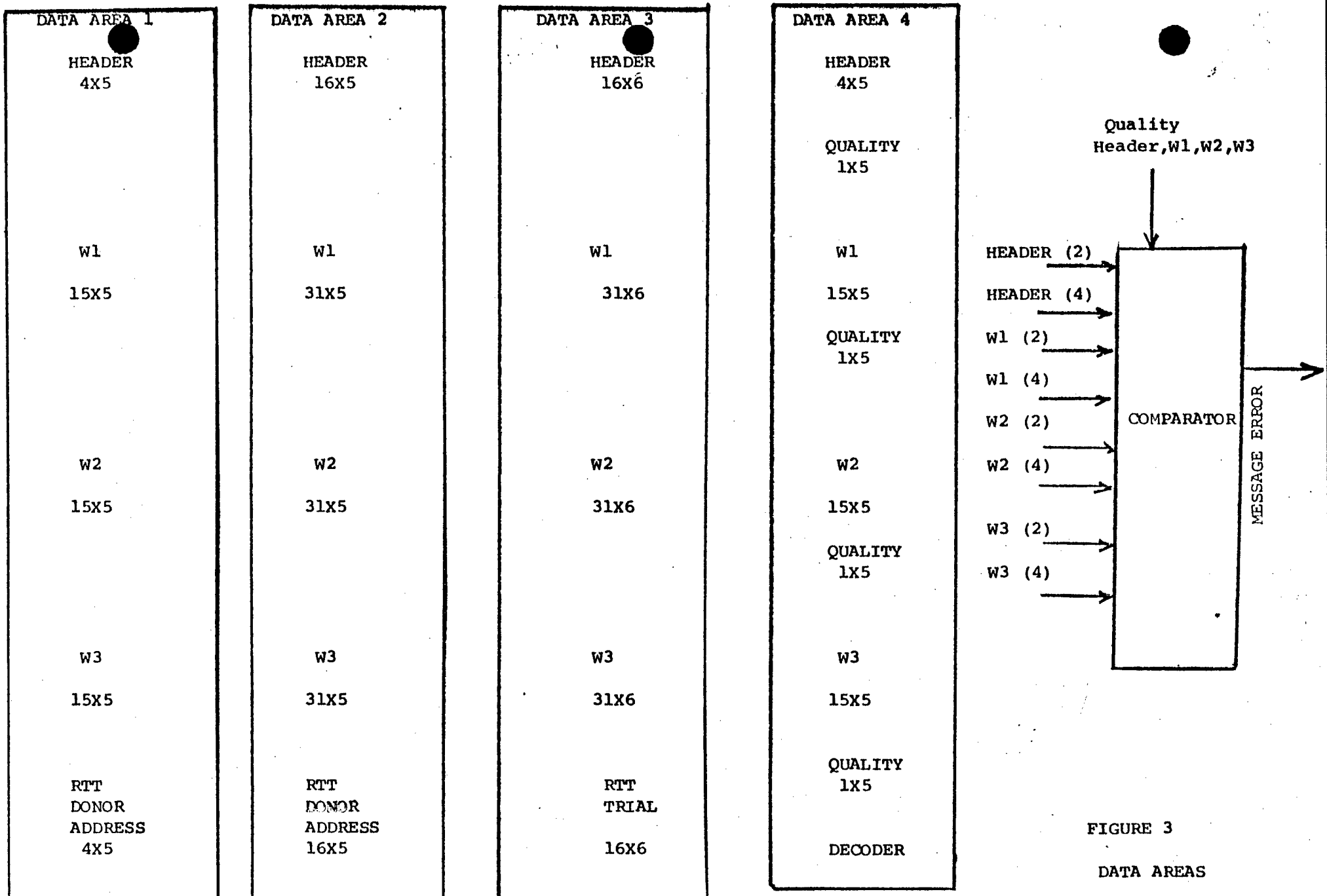


FIGURE 3

DATA AREAS

Mode Control - Encode

In this mode of operation, the input data area (see Figure 3). shall be encoded and the resulting encodes shall be deposited in the encode and errata data areas when the start pushbutton is pushed.

Mode Control - Decode

In this mode of operation, the errata data area shall be decoded and the decoder output shall be stored in the decoder data area.

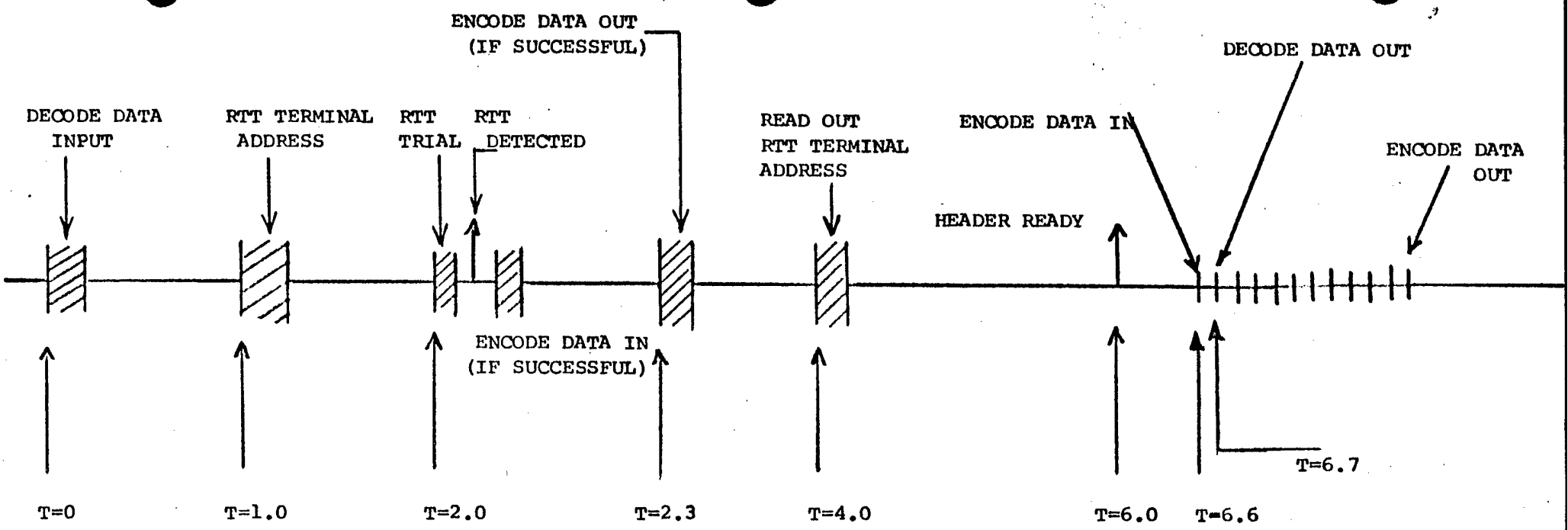
Mode Control - RTT Trial

In this mode of operation, the RTT Trial word of the Errata data area shall be inputted to the RTT detector. If a RTT is detected, the header from the input data area shall be encoded. The resulting encode need not be stored.

Mode Control - Interleaved

In this mode of operation, a slot timing sequence shall be generated as per Figure 4. , At t = o, a decoder data input sequence shall be started and the control signals shall be as per Figure 4. JTIDS User Interface. At t = 1.0 msec, see table 1, the RTT Donor Address (Input Data Area) shall be encoded and deposited into Encode Data area. At t = 2.0 msec an RTT Trial shall be started and if detected as a valid RTT Interrogation, then at t = 2.3 msec a header encode shall be started. At t = 4.0 msec, the RTT Donor Address shall be read out of the RSED to the JTIDS I user. At t = 6.6 msec, an Encode sequence shall be started and at 6.7 msec thru 7.6 msec in 0.1 msec steps the decoder output sequence shall be started. The 6.7 thru 7.6 msec delay shall be a behind the panel control. The decoder output sequence shall interrupt the encode sequence for the length of time it takes to complete the decode output.

During the time that the decoder data is being outputted to the decoder data area, the quality bits for each word shall be checked for a decoder failure and the data portion of each word (Header, W1, W2, and W3) shall be compared against the data for the respective word stored in the Input area. A message error shall be declared if the decoder failure bit of any word is set or the comparison check for any word indicates a mismatch.



TIMES ARE IN MILISECONDS

FIGURE 4

INTERLEAVED TIMING

TIMING SEQUENCE	START TIME	DATA TAKEN FROM AREA	DATA DEPOSITED TO AREA
Decoder Data Input Header, W1, W2, W3	t = 0	Errata	Microprocessor
RTT Donor Address	t = 1.0 msec.	Input RTT Donor Address	Encode RTT Donor Address
RTT Trial	t = 2.0 msec.	Errata RTT Trial	-
Encode (If RTT Trial gives an RTT Detected Pulse)	t = 2.3 msec.	Input Header	To JTIDS I User
Output RTT Donor Add.	t = 4.0 msec.	Encode RTT Donor Add.	To JTIDS I User
Header Out Early	t = 6.0 msec.	Respective Storage Area	To JTIDS I User
Encode Header, W1, W2, W3	t = 6.6 msec.	Input	Encode (ONLY)
Decoder Output Header, W1, W2, W3	t = 6.7 thru 7.6 msec. in 0.1 msec. steps	Microprocessor	Decoder

TABLE 1 INTERLEAVED SEQUENCE START TIMES AND DATA ROUTING

TEST POINTS

Figure 5 shows an overall block diagram of the Reed Solomon Encoder/Decoder with test points of key input/output signals shown in numbered ballons. Table 2 summarizes the key test points. Figures 6, 7, and 8 show additional detail for Encoder/Decoder input/output timing waveforms. The line over the test point indicates that the waveform is the inverse to that shown.

ENCODER TIMING

The encoder timing can be measured as follows:

Enter data into the input data area as previously described. Set Mode to Encode, Number of Messages to 0001, Continuous to On and press the start switch.

Observe the following timing waveforms using a Tektronix 475 or equivalent oscilloscope.

Scope Settings: Sync - External + (Test Point 12)

ModeTriggering - Alt

Vertical Inputs: Channel 1 - Test Point 1, DC

Channel 2 - Test Point 14, DC

Scope Gnd - Test Point G

Adjust vertical gain for approximately 3 cm. deflection for Ch 1 and Ch 2.

Horizontal display - 1 msec per cm - "A" inten

Delayed Sweep - 0.1 msec/cm

Delayed Time Multiplier - 630

Horizontal Display - B Dly'd

The Header encode time interval is measured from the last positive transition of the signal on channel 1 to the first positive edge transition of the signal on channel 2. The time between pulses on channel 2 represents the encode time for W1, W2 and W3.

DECODER TIMING

The decoder timing can be measured as follows:

Enter data Errata into the Errata data area as previously described. Set Mode to Decode, Number of Messages to 0001, Continuous to On and press the start switch.

Measure the decoder turnaround time using a HP5345 Counter as follows:

Counter Settings

Function - time interval

Gate time/display - 100 ms/100 ms

Sample Rate - CCW

Channel A	Channel B
level - preset	preset
Slope +	-
Atten 1 megohm, X20	1 megohm, X20
AC/DC AC	AC
Com/Sep Com A	

Connect a BNC coax cable to test point 13 (Hot Lead) and ground to test point G and the other end is connected to Channel A of the Counter. The counter will display the decode time of a complete message consisting of the Header, W1, W2 and W3.

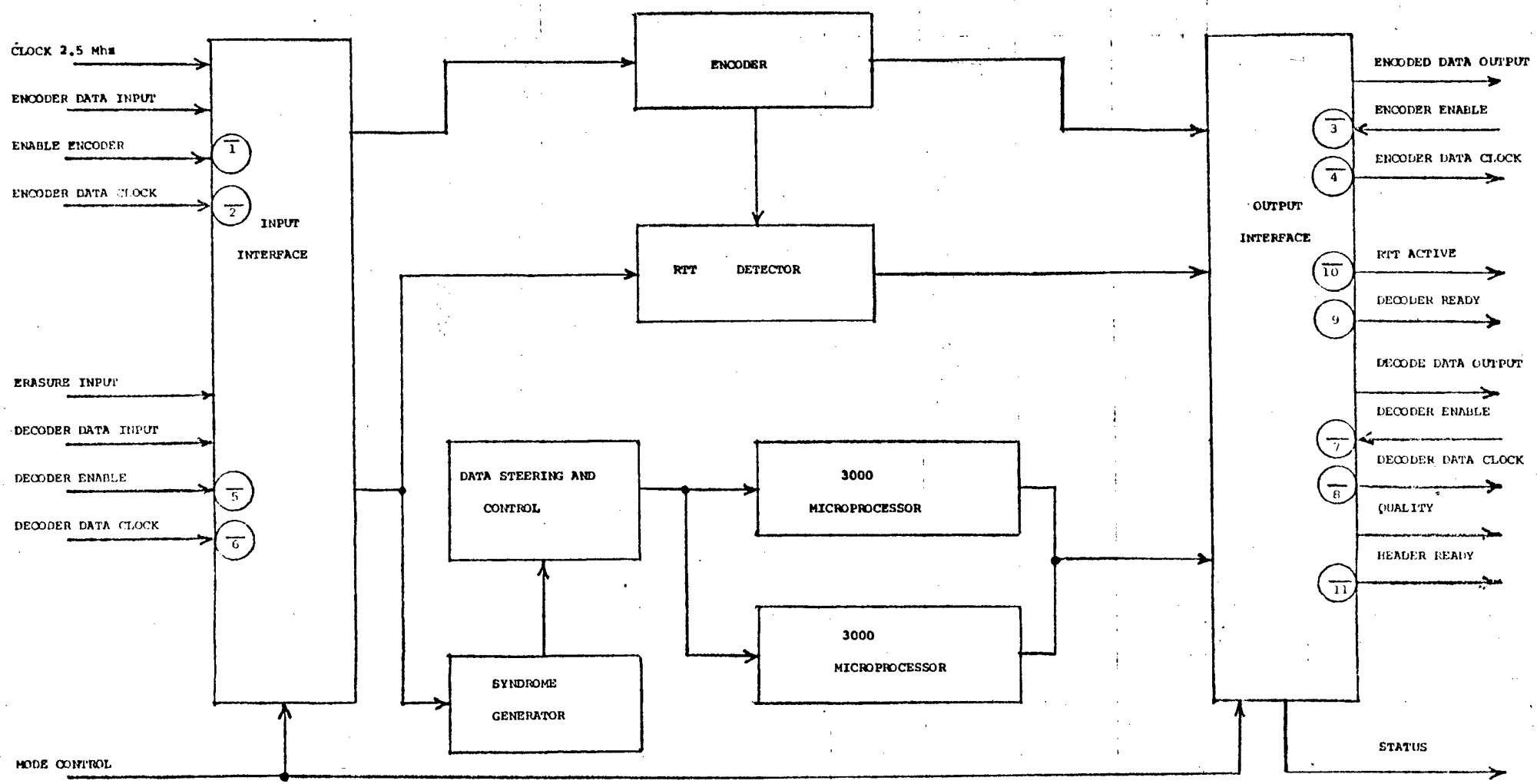


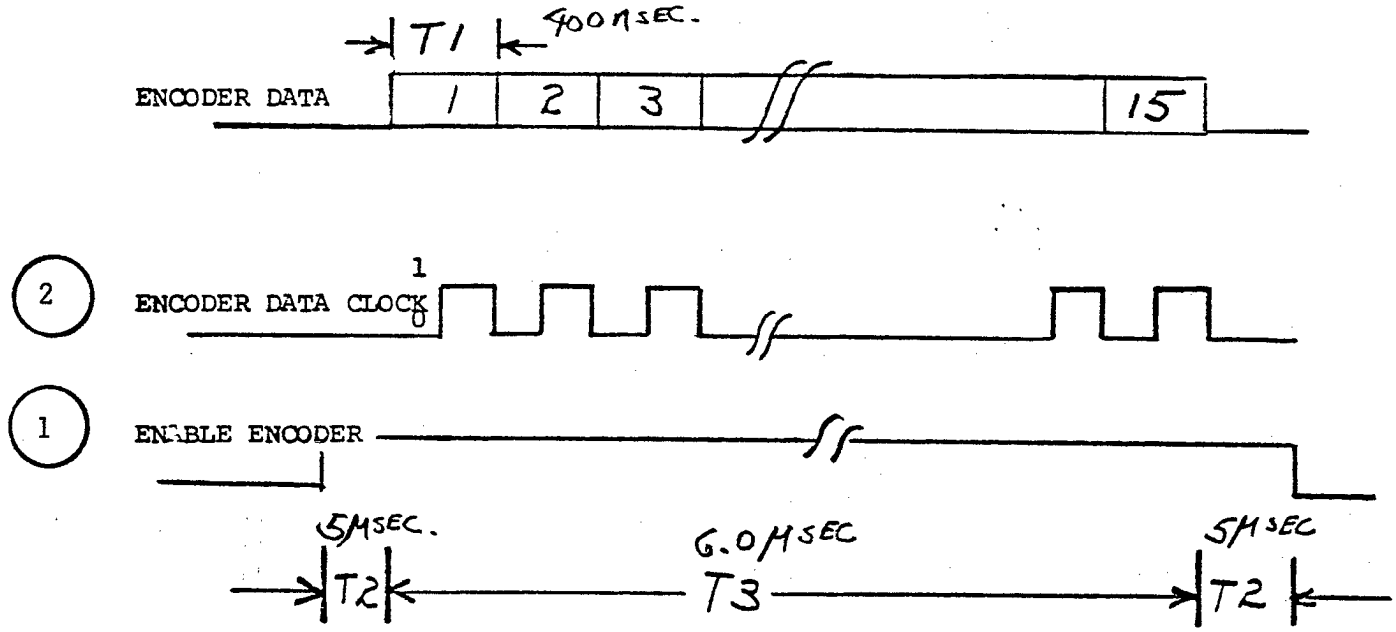
FIGURE 5

RSED BLOCK DIAGRAM

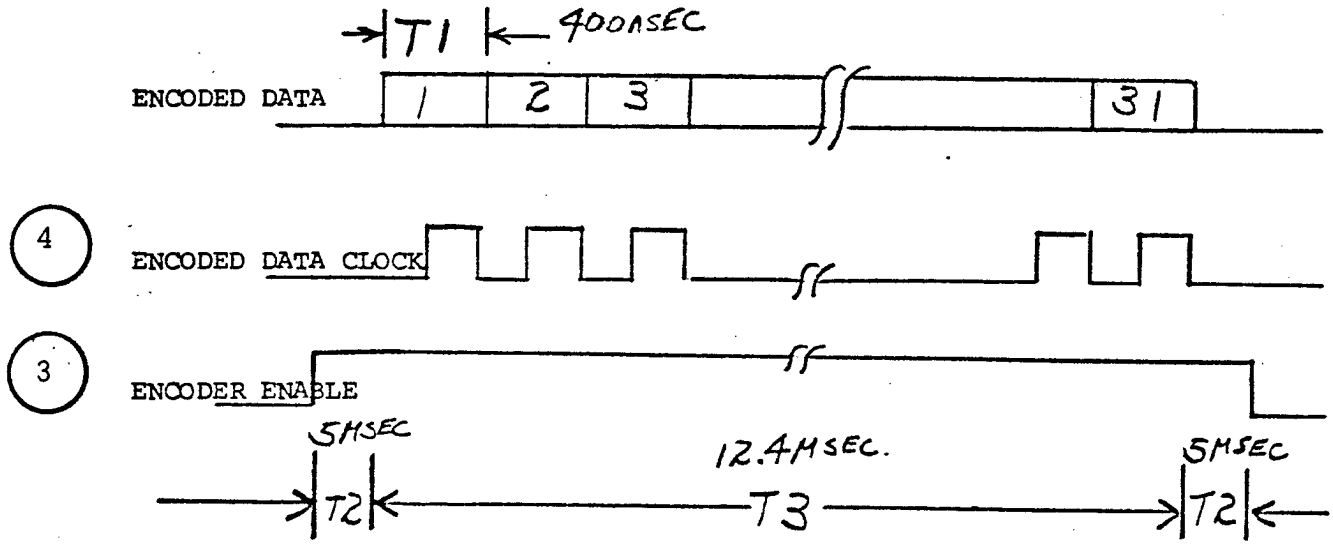
TABLE 2

RSED TEST POINTS

TEST POINT NUMBER	DESCRIPTION
1.	INPUT ENABLE ENCODER (ENCODER START)
2.	INPUT ENCODER DATA CLOCK
3.	OUTPUT ENCODER ENABLE
4.	OUTPUT ENCODED DATA CLOCK
5.	INPUT DECODER ENABLE
6.	INPUT DECODER DATA CLOCK
7.	OUTPUT DECODER ENABLE
8.	OUTPUT DECODER DATA CLOCK
9.	DECODER READY
10.	ROUND TRIP TIMING ACTIVE
11.	HEADER READY
12.	T=0,START OF SLOT
13.	DECODER TIME (FOR 4 WORDS)
14.	ENCODER COMPLETION



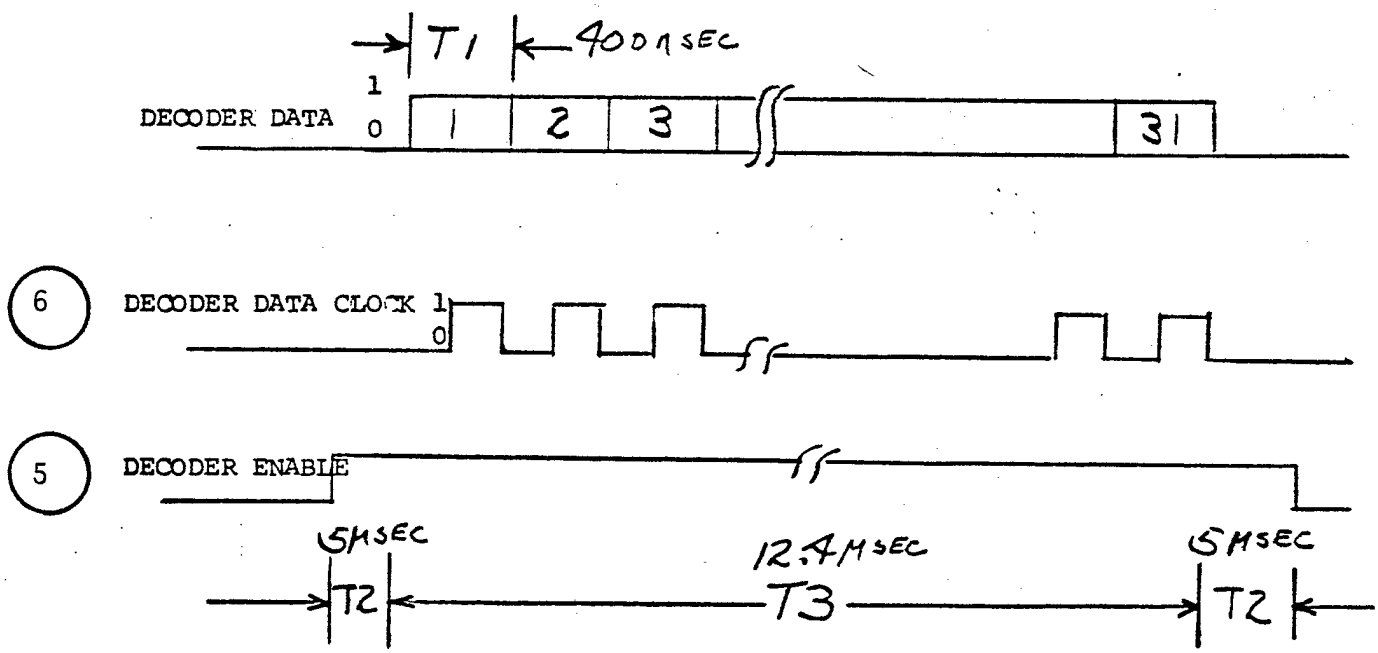
ENCODER INPUT SIGNALS



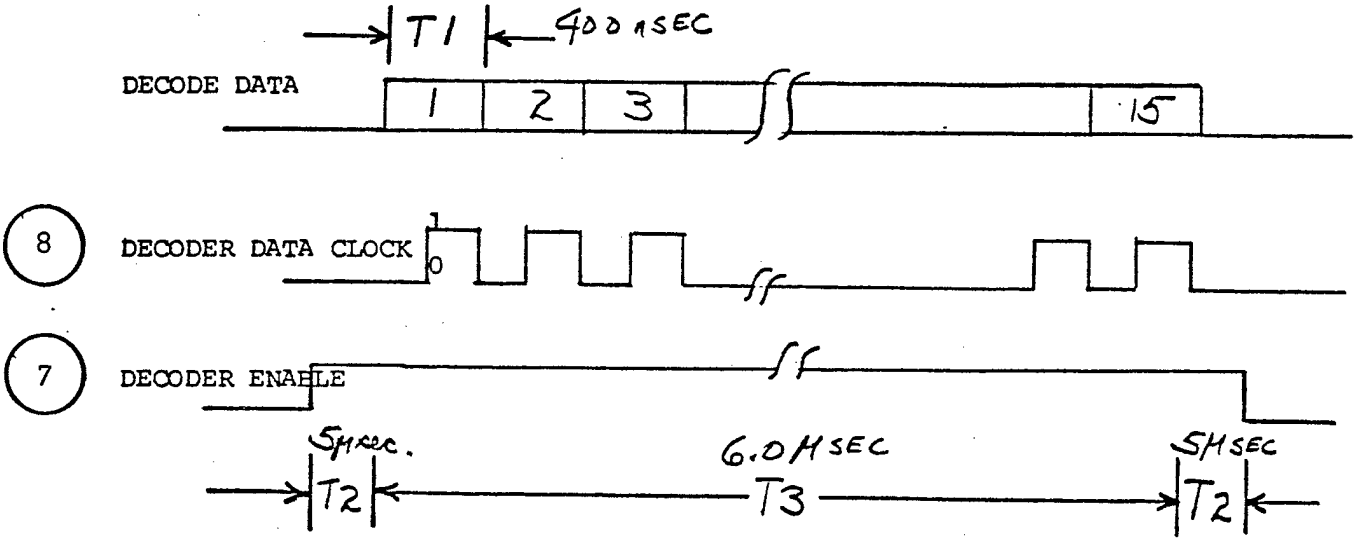
ENCODER OUTPUT SIGNALS

FIGURE 6

ENCODER SIGNALS



DECODER INPUT SIGNALS



DECODER OUTPUT SIGNALS

FIGURE 7

DECODER SIGNALS

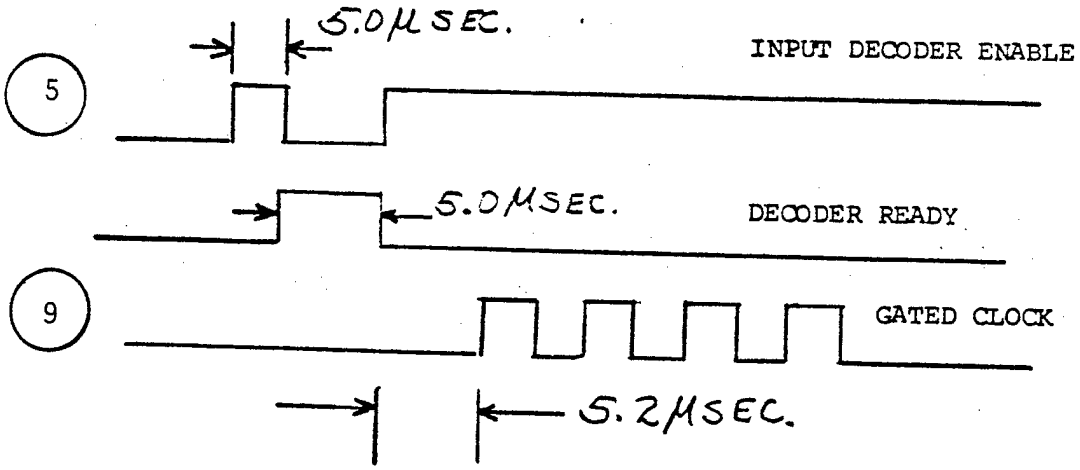


FIGURE 8

DECODE READY